

CLAIMS

What is claimed is:

1. A method for preparing a sequentially functionalized polymer, the method comprising:

reacting an anionically polymerized living polymer with a functionalizing agent X' to produce an end-functionalized polymer that will react or interact with carbon black, silica, or both and that comprises a reactive electrophilic or nucleophilic site; and

reacting the reactive site with a functionalizing agent Y' to produce a sequentially functionalized polymer that will react or interact with carbon black and silica.

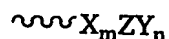
2. A vulcanizate prepared by:

vulcanizing a rubber formulation comprising at least one vulcanizable rubber and a filler, where the at least one vulcanizable rubber is a sequentially functionalized polymer that is prepared by

reacting an anionically polymerized living polymer with a functionalizing agent X' to produce an end-functionalized polymer that will react or interact with carbon black, silica, or both and that comprises a reactive electrophilic or nucleophilic site; and

reacting the reactive site with a functionalizing agent Y' to produce a sequentially functionalized polymer that will react or interact with carbon black and silica.

3. A functionalized polymer defined by the formula



where $\sim\sim\sim$ is an anionically polymerized polymer segment, X comprises a first functional group that will react or interact with carbon black, silica, or both, Y comprises a second functional group that will react or interact with carbon black, silica, or both, Z is a bond or a chain-extending group, and m and n are each integers from 1 to about 50, with the proviso that when X will react or interact with carbon black but not with silica, Y will react or interact with silica, and when

X will react or interact with silica but not with carbon black, Y will react or interact with carbon black.

4. The method of claim 1, or the vulcanizate of claim 2, where the anionically
5 polymerized living polymer is a copolymer of styrene and 1,3-butadiene.
5. The method of claim 1, or the vulcanizate of claim 2, where X' comprises 1,3-
dimethylimidazolidinone, N-methylpyrrolidinone, dicyclohexylcarbodiimide,
benzonitrile, a substituted nitrile, a substituted aziridine, a thiazoline, a
10 dialkylaminobenzaldehyde, a bis(dialkylamino)benzophenone, a substituted epoxy
compound, N-methylcaprolactam, a substituted Schiff base, a substituted
styrylmethyl derivative, vinyl pyridine, a short block of polyvinylpyridine, a
polysulfoxide, a poly(carbodiimide), a poly(meth)acrylamide, a
poly(aminoalkyl(meth)acrylate), polyacrylonitrile, polyethylene oxide, butyl
15 glycidyl ether, monoglycidyl siloxane, polysiloxane with epoxide endgroups,
diphenyl ethylene, or a functionalized styrene.
6. The method of claim 1, or the vulcanizate of claim 2, where X' comprises 1,3-
dimethylimidazolidinone, 3-glycidoxypropyltrimethoxysilane, N-
20 methylpyrrolidinone, or monoglycidyl ether terminated poly(dimethylsiloxane).
7. The method of claim 1, or the vulcanizate of claim 2, where Y' comprises a
silane, alkoxy silane, alkoxy alkyl silane, alkoxy halo alkyl silane, epoxy-generating
reagent, substituted acid chloride, substituted isocyanate, substituted benzylic
25 halide, substituted allylic halide, substituted α,β -unsaturated ketone, α,β -
unsaturated ester, α,β -unsaturated amide, or bis(dialkylamino)phosphoryl
chloride.
8. The method of claim 1, or the vulcanizate of claim 2, where Y' comprises
30 gamma-isocyanatopropyl-triethoxysilane, gamma-isothiocyanatopropyl-
triethoxysilane, gamma-isocyanatopropyl-trimethoxysilane, gamma-
isothiocyanatopropyl-trimethoxysilane epichlorohydrin, epibromohydrin,

triethoxysilyl propyl chloride, diethoxymethylsilyl propyl chloride, and diethylcarbamyl chloride, 1-(3-bromopropyl)-2,2,5,5-tetramethyl-1-aza-2,5-disilacyclopentane, or a multi-epoxidized, high-vinyl, poly- or oligo-butadiene or a poly- or oligo-isoprene.

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9. The method of claim 1, or the vulcanizate of claim 2, where Y' comprises a short-chain polymer group.

10. The method of claim 1, further comprising the step of reacting the reactive site with a chain-extending group Z to form a chain-extended functionalized polymer that comprises a reactive electrophilic or nucleophilic site.